

Sustainable Development Strategy of Urban Metabolism in China

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Abstract

Were studied in this paper, from the Angle of entropy and dissipative structure, sustainable urban metabolism strategies on rapid urbanization in China's eastern coast and the Beijing and Tianjin areas, explored urban development path from the incremental urban to the flow urban and stock urban: on the one hand, with the concept of ecological again, repair damaged in urban natural environment and landscape, improve the ecological environment quality. On the other hand, with the concept of renewal and mending, urban facilities, space environment and landscape features are restored to enhance urban characteristics and vitality.

Keywords

Entropy, Dissipative structure, Sustainable urban metabolism strategies, Flow & Stock urban, Ecological restoration, Urban repair

1. Urban Metabolism: from Negative Entropy to Dissipative Structural Functional System

1.1. Negative Entropy Theory

An Urban is a living organism. "Living things depend on negative entropy." The so-called negative entropy refers to the biological "metabolism", refers to the life body through eating, drinking, breathing and other links can reduce the entropy of the body. Famous Austrian physicist, the founder of quantum mechanics Schrodinger in 1944 in his book "*WHAT IS LIFE*", put forward the famous judgment, he thinks: a living organisms are in constant entropy increases, when the maximum entropy to, that is death, to escape death, will have to live, there is only one way to absorbing the negative entropy from the environment to offset the body is the entropy increase. Negative entropy refers to the life by eating, drinking, breathing can reduce the entropy in the body, biology, called "metabolism".

1.2. Dissipative Structure Theory

The "Dissipative Structure Theory" proposed by Belgian physicist Prizin is a sublimation of the "Negative Entropy Theory". A nonlinear open system far from the balance state, whether physical, chemical, biological and social and economic system, through the exchange of matter and energy with the outside world, constantly at some parameter changes within the system reaches a certain threshold, through fluctuation, system may mutate the non-equilibrium phase change, from chaos state into a function of



time, space, or on the order. The new stable macroscopic ordered structure formed in the nonlinear region away from equilibrium is called "Dissipative Structure" because it needs to exchange material or energy with the outside world constantly to maintain.

1.3 The Dissipation of Urbans

All life is a dissipative structure. An urban is a self-organizing system with a complex dissipative structure, which forms an urban metabolism system with internal relations through the basic operation of ecological flow, material flow, energy flow, resource flow, service flow and geochemical cycle.

Threshold of urban metabolism: according to the research conclusion, when a population of more than 30% of urbanization, entered the stage of accelerated urbanization, industrial scale expands rapidly, the agricultural population to the city quickly gathered themselves together, and this stage due to the large-scale industrialization, resource, energy consumption level is high, the urban metabolism efficiency is low, the entropy increase rather than decrease. The gradually dense population scale and production activities lead to maladjustment of urban metabolism system: water resources shortage, extensive land occupation, air pollution, energy shortage and increase of solid wastes bring unbearable weight to urban metabolism.

When the urbanized population reaches 70%, urbanization begins to step into a stable and mature stage. After the large-scale migration of agricultural population, the economy, life and environment will be greatly improved, the development and utilization of resources and energy will tend to be intensive, and the negative entropy will increase. Urban metabolic system is less dependent on natural resources. As urban resources enter the stage of optimal allocation, the destructive interference to urban ecosystem is reduced and urban metabolic efficiency is constantly improved.

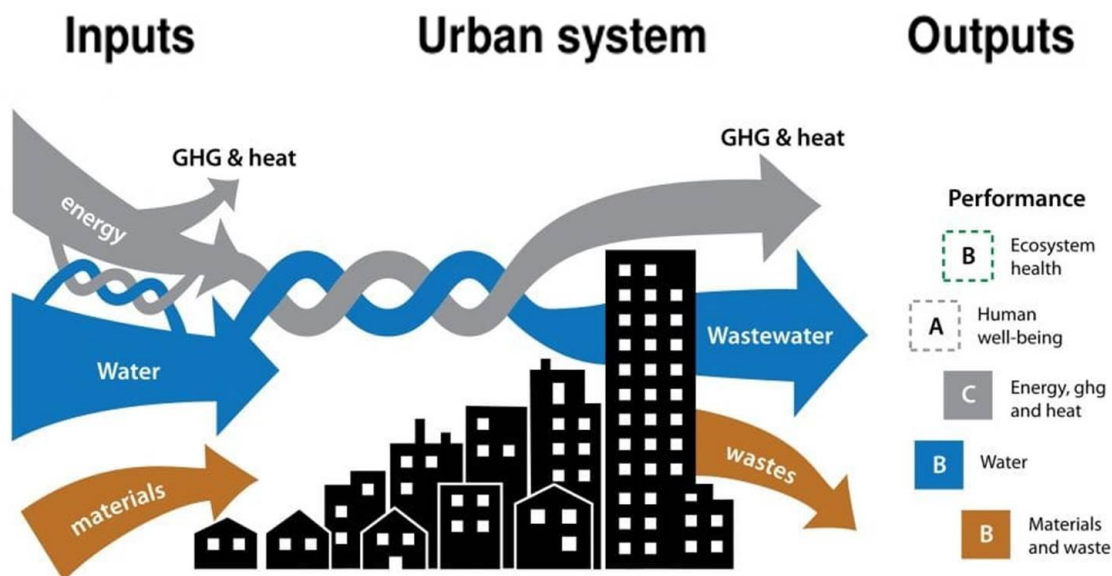


Figure 1. Urban metabolism. Source: Network.

2. Spatial distribution characteristics of urban metabolism in China

2.1 China's urbanization development level

China's eastern coastal areas and Beijing and Tianjin have witnessed rapid economic growth and accelerated industrialization. As a result, the population of the central and western regions is concentrated in the cities of the eastern coastal areas and the Beijing-Tianjin area. The rural agricultural population of the eastern seaboard is also concentrated in local cities. Thus formed the present

urbanization regional development pattern. By the end of 2019, China's urbanization level was about 60.6%. Thirteen provinces and cities have more permanent urban residents than the national average, among which Shanghai, Beijing, Tianjin, Guangdong, Jiangsu and Zhejiang have more than 70%. Shanghai has the highest urbanization rate of 88.10% of its permanent population, Beijing ranks second with 86.60%, and Tianjin ranks third with 83.48%.

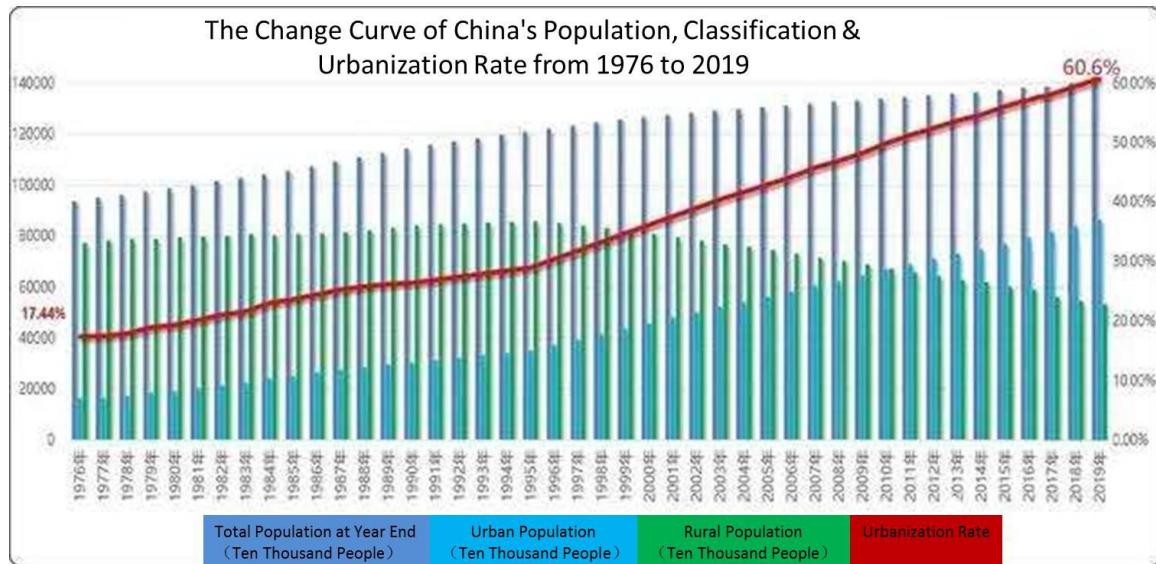


Figure 2. The Change Curve of China's Population, Classification & Urbanization Rate from 1976 to 2019. Source: Draw according to relevant official data.

2.2 Spatial distribution characteristics of urban metabolism in China

Rapid urbanization requires a huge flow of matter and energy. If China's urbanization, which has experienced decades of rapid growth, is regarded as a dissipative structural system away from an unbalanced state, and is significantly affected by natural and geographical conditions, Chinese cities now show the spatial distribution characteristics of "increasing entropy in the west and decreasing entropy in the east".

Urbans in central and western China are "stock operation" mode. Under the path dependence of resource industry, they consume a lot of resources and environment in the early stage, their metabolic efficiency gradually decreases. When urban has reach the intermediate stage of industrialization, the metabolic efficiency level drops to the bottom of u-shaped curve.

The eastern coastal open urbans and the world urbans such as Beijing and Shanghai are "flow operation" mode, and the metabolic rate of resources, environment and ecology has been steadily increased. Topography and climate conditions determine that the eastern region is more suitable for population residence and industrial development, while the location of land and sea determines that the eastern region has better export-oriented economic conditions, which promotes the development of its industrialization, and the industrialization process has entered a high-level stage. The drastic changes of economic structure and industrial structure, the game of industrial transformation, environmental policies and scientific and technological innovation and other factors have accelerated the pace of urbanization in these regions, gradually highlighted the regional functions of cities, formed intercity flow network and accelerated urban metabolism.

The Urbanization Rate of China's Provinces & Urbans



Figure 3. The Urbanization Rate of China's Provinces & Urbans Source: China Statistical Yearbook.

3. China's sustainable metabolic pattern path exploration

A closed entropy system cannot absorb negative entropy from the external environment to reduce the entropy within itself. China is exploring a sustainable development model and has adopted a series of reform measures to this end. From the perspective of symbiosis with nature and people orientation, to guide the evolution mechanism of urban system, the state proposes a new modern governance model: regarding the urban as an organic life body, persisting in paying attention to the whole life cycle and the whole health process, and carrying out the whole life cycle management of the urban. As rapidly urbanizing areas, China's eastern coastal areas and The Beijing-Tianjin region are the first to explore the urban metabolism model of sustainable development and governance of megacities. On the one hand, promote flow operation. Based on the change of the path, direction, intensity and rate of ecological flow, the ecological continuity of different scales in different regions and urbans can be restored with the concept of re-ecology, so as to improve the damaged natural environment and topography, and improve the quality of ecological environment. On the other hand, improve the stock operation. With the concept of renewal and mending, urban facilities, space environment, landscape features are restored to enhance urban characteristics and vitality. These two aspects explore how to change the ac retardation of urban entropy increase system and the loss of negative entropy.

3.1 Ecological restoration promotes flow and increases negative entropy

Ecological restoration refers to the function of damaged urban natural environment, supplemented by artificial measures, to guide the natural environment to gradually repair itself, absorb negative entropy, and promote the virtuous cycle operation system of urban ecological system. China attaches great importance to ecological restoration and has continued to increase investment. Remarkable results have been achieved in major ecological projects such as large-scale land greening, wetland, river and lake protection and restoration, desertification prevention and control, water and soil conservation, biodiversity protection, comprehensive land improvement, and Marine ecological restoration. At the national level on the top of the design, in June 2020, by the National Development and Reform Commission and the Department of Natural Resources also issued by *THE NATIONAL MAJOR PROJECT IMPORTANT ECOSYSTEM PROTECTION AND RESTORATION MASTER PLAN (2021-2035)*, in order to improve

quality of national ecological security barrier, promote the ecosystem virtuous circle and sustainable utilization for the overall goals, plan as a whole mountain, water, forest, farm, lake, grass integrated protection and restoration. Large urbans of China's eastern coastal areas and The Beijing-Tianjin area have mainly carried out ecological restoration work in the following aspects.

3.1.1 Carry out water system governance and water ecological restoration

From the perspective of hydrological cycle, a modern urban water environment metabolic system is constructed, which mainly includes ecological restoration of coastal waters and coastal zones, water system protection and water environment treatment (blue line management), ecological restoration of natural wetlands, and sponge urban construction planning.

(1) Ecological restoration of coastal waters and coastal zones

The coastal zone ecosystem is composed of many types of ecosystem, which belongs to transitional ecosystem ecologically. It is generally believed that the coastal zone ecosystem is composed of four typical ecological (sub-) systems, including coastal ecosystem and offshore Marine ecosystem, as well as some terrestrial ecosystem (such as forest, grassland, etc.) and some wetland ecosystem (such as beach, marsh, etc.).Habitat is usually combined in space, and different habitats are interconnected. Therefore, the restoration of coastal ecosystem should adhere to the land-sea overall planning, and give priority to the comprehensive treatment and restoration of estuaries, gulf pollution sources and typical coastal ecosystems.

For coastal zones with prominent ecological and environmental problems, corresponding ecological restoration work should be carried out in accordance with the distribution of major problem areas or typical ecosystems. For the coastline with severe erosion, it is necessary to construct offshore Banks and artificially raise beaches, gradually restore the natural ecology of the coast, and improve the conservation rate of the natural coastline. For greatly influenced by artificial reclamation and other human activities around the characteristics of ecosystems such as wetlands, such as mangroves, seaweed bed, national parks, delimit the nature reserve, ecological red line for delineating in-place protection, or exit the farming fishery, wetland restoration, and restore the beach, to restore habitat, improve Marine productivity, restore the vitality of Marine, improve the ecosystem service function.



Figure 4. Measures and achievements for ecological restoration of coastal waters and coastal zones in China's coastal urbans Source: According to the Internet and Media information

From the practice effect by wharf demolition waste, waste disposal, and marine dredging, repair the natural coastline, treatment of artificial coast and offshore submerged breakwater construction, seawall built, coastal view corridor build, sand control repair and geological relics landscape restoration, can effectively improve the coastal ecological environment, to provide more high quality water space.

(2) Water system protection and water environment treatment

In the climax of urbanization, the environment and natural ecological community of biological reproduction in the original river course and lake were destroyed, making the urban water system lose the ability of self-purification. In many places, urban river management mechanically implements the design standard of "once in $\times\times$ years" or "one size fits all", simply cutting off the curve and making it straight, which causes huge economic waste. Moreover, the tall flood levees inside the urban seriously affect the original urban drainage, traffic system and ecological system. The new idea of water environment treatment is to strengthen the protection of the natural form of the urban water system, delimit the blue line of the urban's rivers and lakes (including reservoirs), strengthen the control of the blue line, and comprehensively improve the black and smelly water body in the urban.

(3) Ecological restoration of natural wetlands

Take Tianjin as an example, the wetland is the characteristic of Tianjin. For this reason, Tianjin formulated "*Tianjin Wetland Ecological Protection and Restoration Plan*". In wetland ecological restoration work, it is proposed to carry out wetland ecological environment assessment regularly and promote wetland nature reserve ecological restoration work. We will focus on restoring natural wetlands in major areas of urban development, strictly controlling the scale of freshwater aquaculture and constructed wetlands, and slowing down land subsidence. We will designate priority areas for biodiversity conservation and update and upgrade biological databases.



Figure 5. "Tianjin Wetland Ecological Protection and Restoration Plan" and its implementation results
Source: Official website

(4) Sponge city construction planning

After the idea of urban stormwater management and rainwater resources utilization entered China, the coastal areas took the lead in practical actions. Since 2014, the construction of sponge cities has become a national initiative, shouldering the two major tasks of protecting water resources and preventing floods. The Ministry of Finance, the Ministry of Housing and Urban-rural Development and the Ministry of Water Resources jointly launched a nationwide pilot city program, and the Ministry of Housing and Urban-rural Development compiled and issued a *"Technical Guide for Sponge City Construction (Trial)"*. By 2015, hundreds of cities across the country had taken action. Each city makes full use of parks, parking lots, residential areas, industrial parks, green belts and other facilities, and builds pervious brick, sunken green space, rainwater garden, grass planting ditch and other rainwater absorption, seepage and utilization projects, to create a sponge city in an all-round way.



Figure 6. Technical means of sponge city construction Source: Case summary and Network

In a lot of practical work, two reflections are made. First, the research shows that under the background of global climate change, the intensity and continuous time of China's heavy rainfall show increased characteristics, and the spatial distribution also changes. Therefore, it is urgent to consider the variation characteristics of the intensity and duration of heavy rainfall in cities in different regions of the country under the background of climate change when planning the recurrence period of urban storm water pipe and drainage design and the recurrence period of waterlogging prevention design, so as to ensure that cities have sufficient drainage capacity and effectively reduce the occurrence of urban waterlogging disasters. Second, in addition to natural factors, the neglect of the integrity of the urban ecosystem in urban construction is also an important reason for the vulnerability of cities in the face of heavy rains and floods. In high-speed urban areas such as the Beijing-Tianjin-Hebei Region, the Yangtze River Delta and the Pearl River Delta, land cover changes at an alarming rate, and construction land expands rapidly and encroachment on farmland, water surface, forest land and other ecological land, which not only disrupts or cuts off the natural surface runoff system of the region (basin), but also occupies a large amount of

diversion and flood storage space. The city is not an isolated Noah's ark, and its flood control and drainage system must be planned and constructed as a whole with the surrounding areas.

3.1.2 Carry out soil pollution control and remediation

Urban soil pollution remediation mainly focuses on the treatment and remediation of soil pollution in agricultural land and land used by enterprises in key industries. According to the principle of "whoever pollutes the soil shall control it", the unit or individual that causes soil pollution shall bear the main responsibility for the treatment and remediation of soil pollution, and a lifelong responsibility system shall be implemented for the treatment and remediation of soil pollution. The urban environmental protection department shall be responsible for establishing the project bank of urban polluted land parcels. The competent environmental protection department shall inform the land use right holders of the suspected polluted land parcels and the list of polluted land parcels. Land use rights holders shall conduct soil environmental surveys in accordance with regulations, compile survey reports, and make the main contents of the reports public through their websites and other ways for the public to know. The owner of the right to the use of the contaminated land shall, on the basis of the risk assessment results and in combination with the relevant development and utilization plans, carry out risk control in a targeted manner.

If the contaminated land parcels to be developed and used for residential land and land for public facilities such as commercial, school, medical and old-age care institutions need to be treated and rehabilitated after risk assessment, the land use right holders shall carry out treatment and rehabilitation. A third-party institution shall, in accordance with the relevant national environmental standards and technical norms, carry out the effect assessment, compile the assessment report and make it public to the public within no less than two months. If the contaminated land has not been treated and rehabilitated, or has been treated and rehabilitated but has not met the requirements for soil environmental quality of the relevant planned land, the competent department of environmental protection shall not approve the environmental impact statement or report form of the corresponding construction project.

3.1.3 Mountain restoration

We will promote the greening of mines, close them, remove mining wound stones through appropriate techniques, and eliminate geological hazards such as avalanches and landslides in mining areas. Use ecological restoration technology to restore and reconstruct the mountain natural ecology. The mining platform should be improved comprehensively to level out the available land resources and rationally arrange the functions in combination with the planning and design. Regularly carry out the mountain ecological environment assessment work, strictly prohibit the destruction of the mountain natural ecological environment construction activities.

3.1.4 Ecological network restoration

Connect the natural ecological network with the artificial ecological network to ensure the smooth flow of ecological channels. First, define and control the urban ecological red line, improve the system of ecological protection red line, carry out ecological space evaluation regularly, and comprehensively guarantee the safety of ecological space. Second, to improve the green space system, strengthen the repair and restoration of urban greenway network system, organize the planning and implementation plan of greenway connection in country parks, build green rings, greenways and green wedges at different levels, and build a complete and coherent urban and rural green space system; Third, the quality improvement and transformation of the stock green space, promote the upgrading of old parks, improve the quality and function of the stock green space. Combined with the construction project of high-quality

residential areas, promote the community supporting greening, strengthen the maintenance and management of green landscape in residential areas, improve the greening service function.

The natural inputs from the outside into the city include air circulation, atmospheric precipitation, river water and underground water flow. These circulation flows connect the living, production, resources, environment, time, space and other components in the urban natural ecosystem as well as the external environment. All these activities can be collectively referred to as "ecological flow". The study of the above four parts aims at dredging and technical treatment of the carrying space of "ecological flow", guiding the urban to absorb negative entropy, and making the natural ecological environment produce stronger self-purification ability.

3.2 Urban repair, increase stock and reduce positive entropy

Within a certain period of time, the total amount of material in urban space is called the current stock of urban system. At the end of its life, such stock of material needs to be dismantled, removed or repaired, and replenished according to human needs. Evolving. Besides circulatory function, the metabolism of urban stock also needs adaptation and inclusion function. Fine management of urban stock and emphasis on the demand of various urban groups can reduce positive entropy.

3.2.1 Improvement of municipal infrastructure

It includes the construction of underground comprehensive pipe gallery and the renovation of old pipe network in new and old urban areas according to local conditions. In particular, the upgrading of old residential areas, combined with the renovation of old residential areas and the renewal of historic and cultural blocks, will intensify the renovation of old urban water supply, drainage, gas, electric power, heating and other old pipelines, and promote the access corridor of various aerial lines in an orderly manner in combination with the conditions of municipal roads, so as to make up for the shortcomings of infrastructure and eliminate safety hazard.

3.2.2 Improve public service facilities

First of all, combined with the deepening work of detailed control planning, further survey the current public service facilities and other supporting facilities, carry out evaluation according to the concept of equalization of community living circle facilities, formulate 15-minute life circle planning, and put forward promotion and improvement guidelines based on the concept of urban repair.

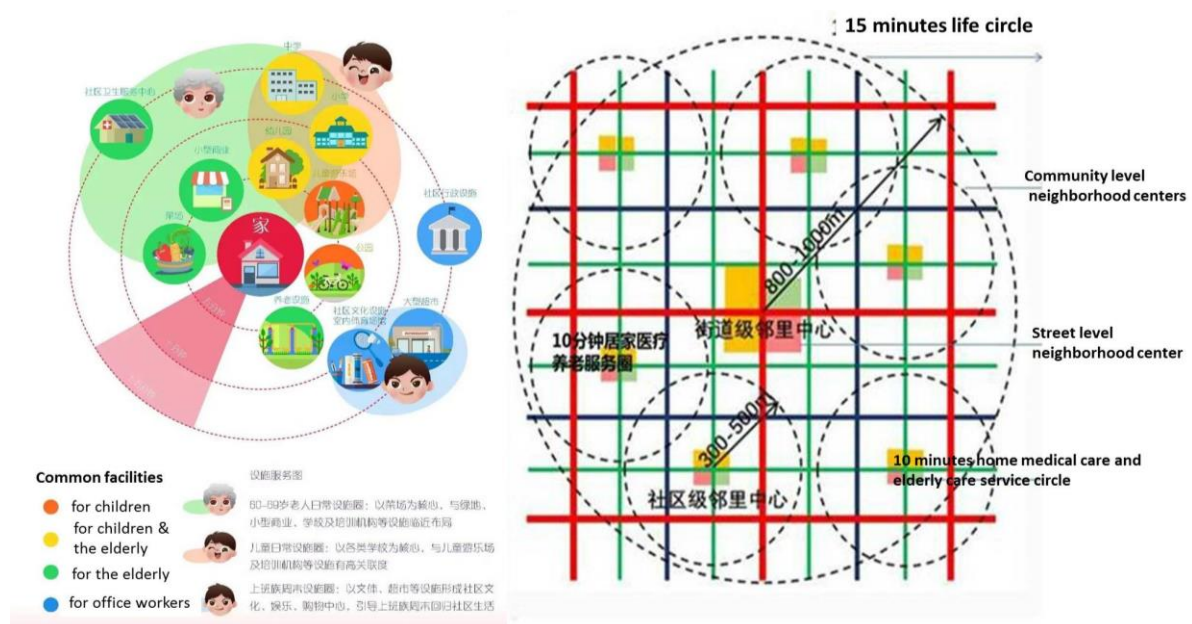


Figure 7. 15-minute life circle planning study Source: Case studies on related subjects

Second, we will promote the construction of public service facilities in light of local conditions. The focus is to improve the construction of barrier-free facilities, day care centers for the elderly, primary and secondary schools, kindergartens and other public service facilities in the old urban areas to meet the requirements of providing care for the elderly and children. To repair and upgrade the existing aging and damaged public service facilities.

Third, in response to public health emergencies, the layout of medical and health facilities should be planned at different levels and in different districts, so as to establish a resilient urban public space system, improve the spatial universality of public facilities, and form an elastic space for emergency use.

3.2.3 Construction of smart city

We will promote the development of smart cities, improve information infrastructure such as the Internet, and strengthen the development of platforms for sharing and exchanging information resources. We will promote the transformation and development of urban management models and improve the level of urban governance.

(1) Urban brain

The so-called urban brain takes the Internet as the infrastructure and makes use of the rich urban data resources to carry out the global real-time analysis of the city. It is an urban data resource platform that meets the requirements of modern urban management and operation. Use the city's data resources to effectively allocate public resources, constantly improve social governance, promotes sustainable urban development. Equip the city with an artificial intelligence brain, and let all the city data through this brain for the most reasonable configuration and scheduling. Data processing of infrastructure, such as transportation, energy and water supply, can save more resources and realize effective urban management.

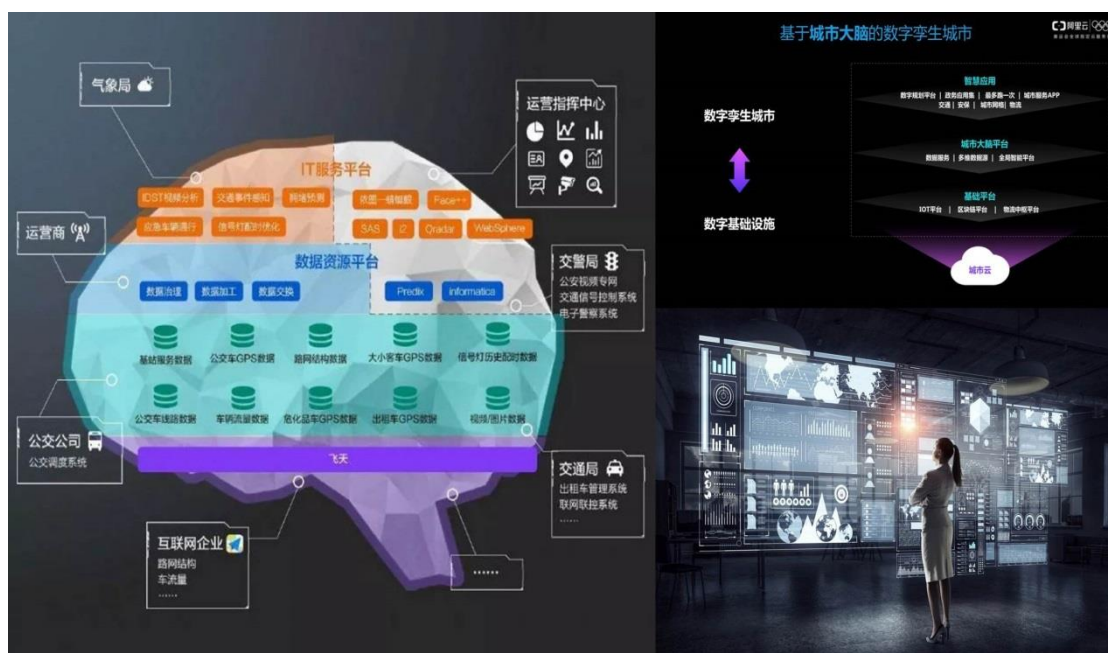


Figure 8. Urban Brain Technology Source: SHANGHAI SMART CITY CONSTRUCTION

(2) Smart community and grid management construction

Environmental monitoring systems, including water resources, noise, air, garbage and other monitoring systems, shall be built in communities and on comprehensive community platforms, and environmental complaint platforms for citizens shall be built to provide a basis for the management of urban environmental management departments.

3.2.4 Improve travel conditions

(1) Road system repair

We should strengthen the planning and construction of blocks, promote the urban road layout concept of "narrow road network", break through the guillotine, form a complete road network, and improve the accessibility of roads.

(2) Traffic improvement in key areas

We will strengthen traffic regulation in urban streets and key areas, optimize existing road sections, and increase channelization facilities at intersections. We will appropriately widen the width of sidewalks in urban centers and transportation hubs, improve crosswalks and barrier-free facilities, promote tree-lined roads, speed up the construction of green roads, and encourage urban residents to travel in a green way. We will strengthen transport links at key points, improve the transfer of various modes of transport, and make it easier for urban residents to travel by public transport.

(3) Additional parking facilities

To solve the problem of parking difficulties, we will encourage the construction of more parking facilities and increase the effective supply of parking Spaces in combination with the renovation and renovation of old and old urban areas, as well as the construction, renovation and expansion of new buildings.

3.2.5 Improve the space system for historical and cultural protection

We will improve the protection and planning system for famous historical and cultural cities, towns, villages and blocks. Strictly control the construction activities around the historic and cultural blocks, strengthen the protection of buildings with historical features in accordance with the law, and improve the repair technology of historic buildings; To better continue the historical context, strengthen the protection and excavation of the traditional cultural value of the historic and cultural blocks around the block, carry out comprehensive pilot planning combining planning and system in combination with the pilot project, and promote the renovation and upgrading of the blocks around the historic and cultural block; In combination with the existing industrial heritage protection planning sequence, industrial sites should be reasonably protected and utilized, and old buildings should be encouraged to be renovated and reused.

The final summary: Metabolic syndrome occurs when the body exceeds its limited capacity for production and purification. The study of sustainable urban metabolism from the perspective of entropy and dissipative structure is to update and improve urban production capacity, guide urban self-purification capacity, and explore the development path from incremental urban to flow urban and stock urban. In the stock of the physical world, urban metabolism is sluggish, a closed loop that retards entropy through urban tinkering. In the physical world of flow, urban metabolism is an open system that introduces absorbable and transformable negative entropy into the urban through urban ecological restoration.